Space Weather Technical Forecast

Issued on Sunday, 26 December 2021 at 12:44 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Slight chance of G1/Minor Storms on 27 and 28 Dec. Reducing chance of M-class flares (R1/R2 Radio Blackout), with slight chance of X-class (R3 Radio Blackout). Slight chance of Active fluence by 29 Dec.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity has been low over the past 24 hours, with several C-class flares observed. This activity was observed mainly from AR2918 and from near the southwest limb, where AR2907 is rotating off the Earth-facing disc. This left 5 sunspot regions on the visible disc, the most notable of which are AR2916 Ekc/Beta in the southeast quadrant and AR2918 Eac/Beta near north centre disc. Despite both being reasonably large, neither has produced anything more than C-class flares in the last 24 hours. All other regions are currently small and simple.
A CME has been observed from a filament eruption in the southwest quadrant, however further imagery is needed to analyse this. No other potentially Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: Solar wind speeds as observed by DSCOVR at L1 were slightly elevated at around 470 km/s, before erratically declining from 25/2200 UTC to reach around 370 km/s. The density was average to start, but declined from 25/2200 UTC to below average. The IMF Bt was weak at 6nT or below, with the Bz predominately negative (southward) orientated varying between +3/-5nT. Phi angle was largely negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at background levels. The high energy electron flux (greater than 2 MeV) reached High levels at times between 25/1445-2000 UTC, and again since 26/1110 UTC. The associated 24-hour integrated fluence has declined slightly through the 24 hour period, and is below the Active threshold. At 26/0000UTC it was 6.15e7 integrated pfu.

Four-Day Space Weather Forecast Summary
Solar Activity: Low solar activity is forecast throughout the period, with a chance of M-class flares and a slight chance of X-class flares. This risk is expected to reduce to a slight chance of M-flares during day 2 (27 Dec), due to AR2907 rotating further away from the Earth-side. However, any further development of AR2916 has the potential to elevate the flare risk again.

Solar Wind / Geomagnetic Activity: There are two potentially Earth-directed CMEs forecast, however both are currently expected to miss, with only weak glancing impacts at most. Ambient solar winds are expected during day 1 (26 Dec) before the arrival of the fast wind of coronal hole 37 on either days 2 or 3 (27 or 28 Dec) with expected speeds of around 500km/s. This is likely to be followed by further fast winds from CH38 and CH39, leading to a broad period of slightly elevated to elevated solar winds. Mainly Quiet geomagnetic activity is forecast through day 1, with a chance of Active and a slight chance of G1/Minor Storms on days 2 or 3. Quiet to Unsettled conditions with a chance of Active intervals then follows.

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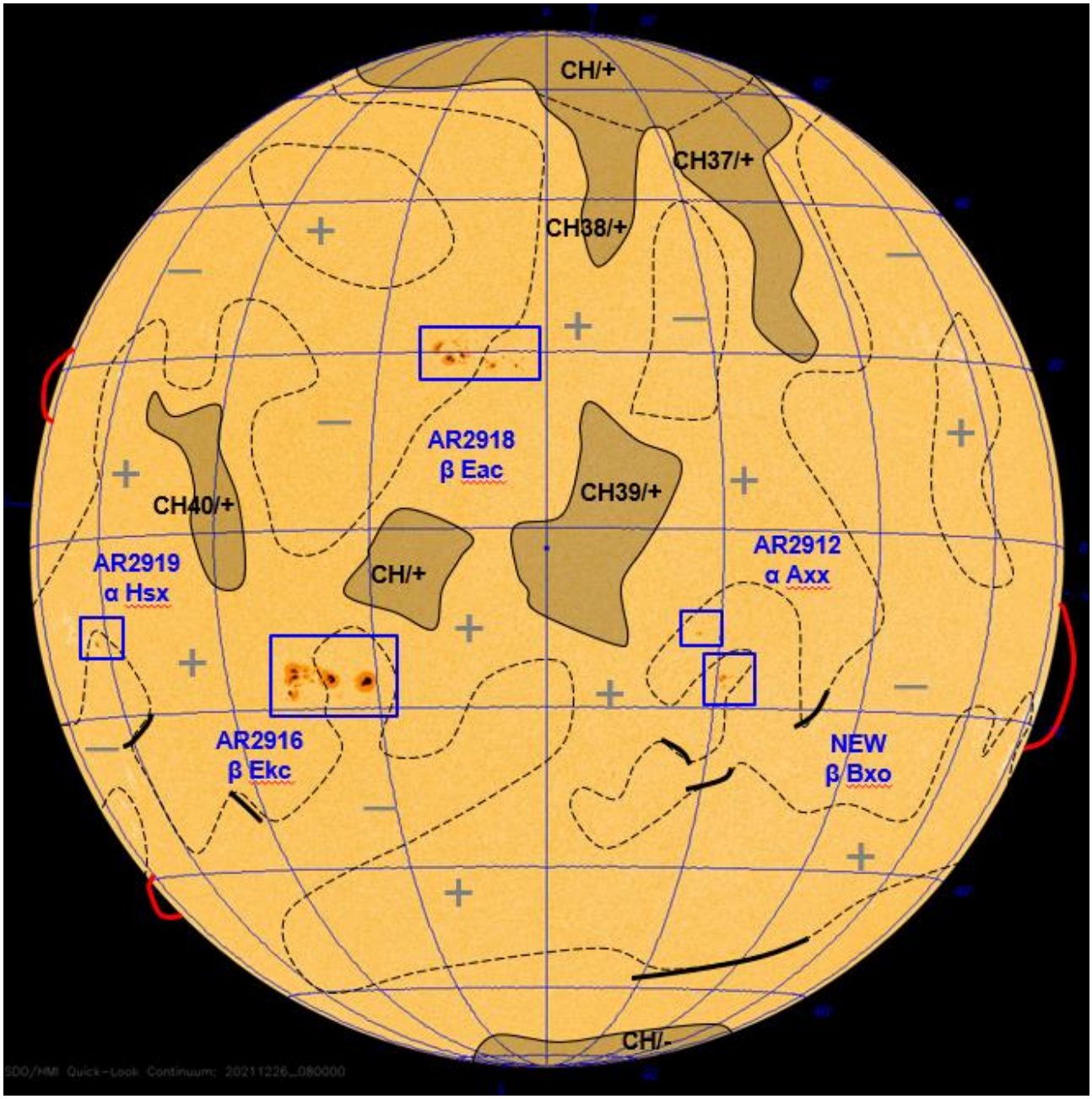
Met Office Space Weather Technical Forecast

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels and below the S1 level, although there is a slight chance for some increased flux from any significant flare activity. High energy electron flux (greater than 2MeV) levels will peak at high levels again today and perhaps tomorrow, with a fall to background likely on days 2 or 3 following any fast wind arrival. Electron fluence is expected to follow a steady or declining trend for much of the period, below the Active (1e8 integrated pfu) threshold, but with a slight chance of rising above again by day 4.

Figure 1. Solar Analysis Valid 26/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two CMEs of current interest for the period, which left the Sun on 21 and 22 December respectively. These may glance the Earth on 26 or 27 December. However, as both were relatively narrow features, there is low confidence in this aspect of the forecast and they could miss entirely.

Coronal hole 37 fast wind is forecast to arrive at Earth on either days 2 or 3 (27 or 28 Dec). This is a new feature on this rotation, with the recurrent feature from the previous rotation being coronal hole 38, which follows 37 closely. This produced speeds of around 500km/s on the previous rotation and similar speeds are assumed on this rotation for either coronal hole. However confidence in timing is low due to the northern location of CH37, and an enhancement only recently observed at STEREO-A. If Earth follows a similar trend to STEREO-A, then we wouldn't expect to see any enhancement until later on day 3. Coronal hole 39 in the central disc is also new on this rotation, and is of a similar longitude to CH38, suggesting similar arrival times, either late day 3 or day 4 (29 Dec). It is possible that once connected to the fast wind of CH37, a broad fast wind will be observed for the period, with enhancements from either CH38 or CH39 difficult to discern.

Geomagnetic activity is expected to be mainly Quiet day 1 (26 Dec), with a chance of Active and a slight chance of G1/Minor Storm intervals on days 2 or 3, due to the anticipated connection with the high speed stream from coronal hole 37. Quiet to Unsettled conditions with a chance of Active intervals then follows.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	20	20	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

CME-202112-016	22/12/2021 07:20	28W	225	475	10	22/12/2021 17:35
CME-202112-015	21/12/2021 19:15	30W	205	319	22	22/12/2021 07:26

Figure 2: AIA-193 imagery showing the previous rotation (left) and the current rotation (right). Several differences are visible between the rotations, making persistence a less useful guide.

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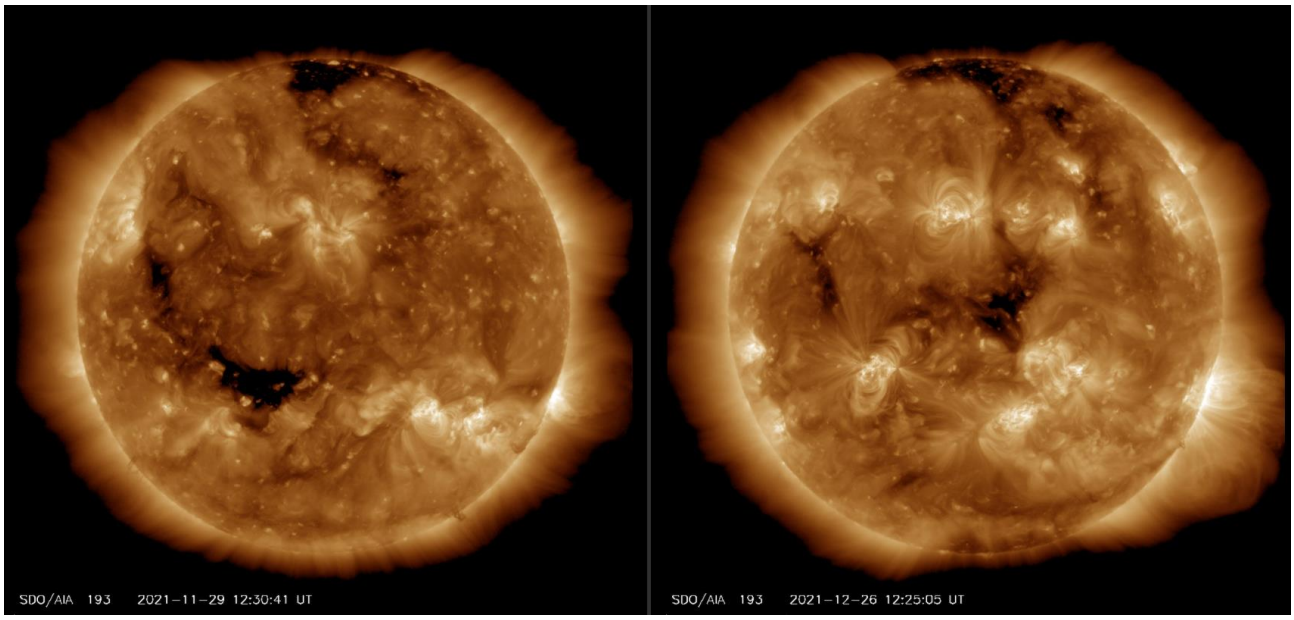
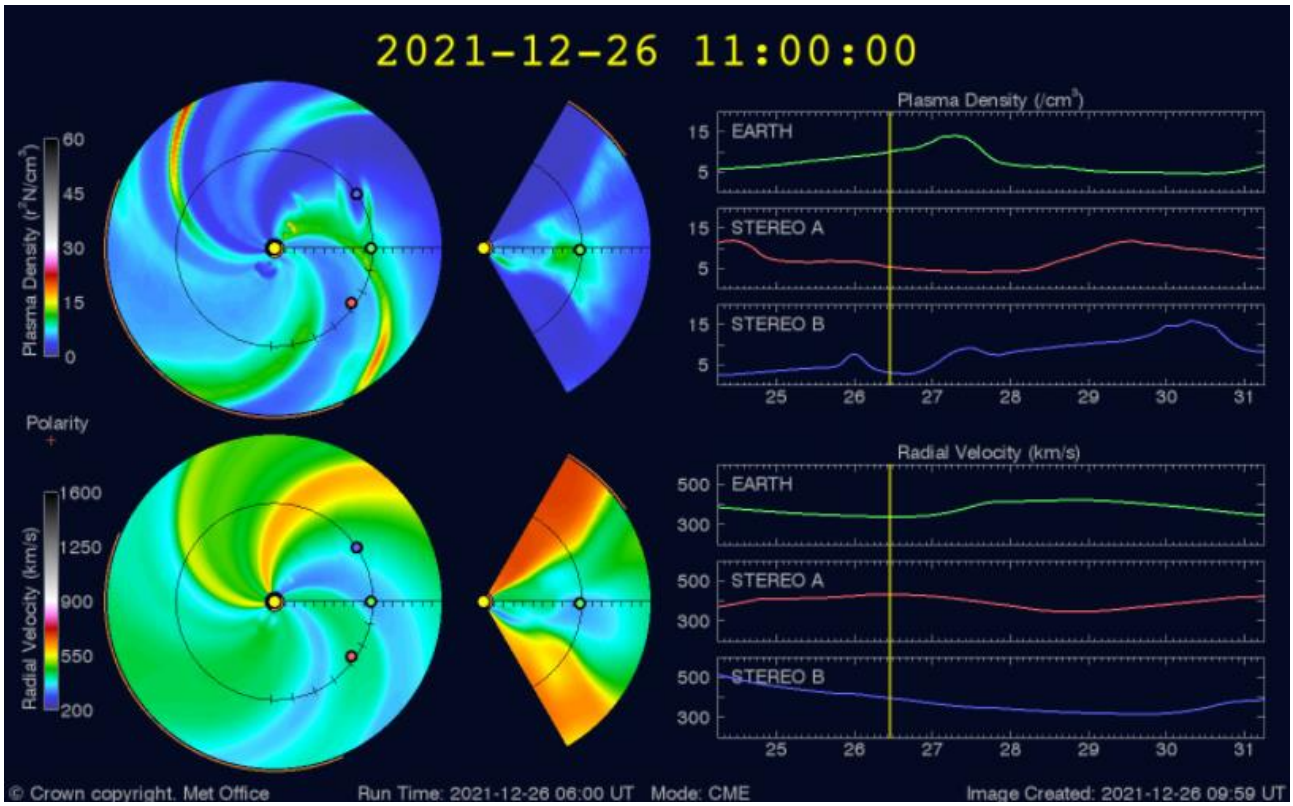


Figure 3: Enlil forecast, perhaps underdoing the coronal hole fast wind enhancement



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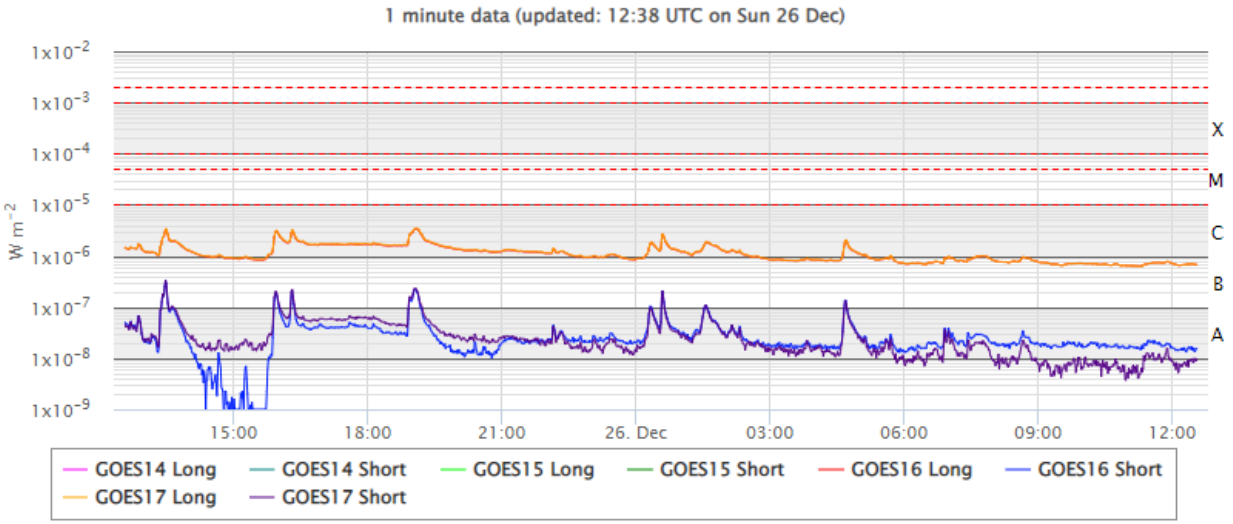
Radio Blackouts - X-Ray Flares:

Solar Activity has been Low, with several small C-flares. There are now 5 sunspot containing active regions on the visible disc. The most prominent is the large AR2916 Ekc/Beta. This region does have a history of producing M-flares, however this was on the 21st, when the region was still behind the limb, with no notable flares since. Its intermediate spot, which did have potential for delta spot development, appears to have separated somewhat with this risk now reduced. This region will need to be monitored for any further development.

A further developmental region AR2918 Eac/Beta is smaller, but is comprised of more numerous umbra regions compared to AR2916. This also has the potential for M-class flaring, and for further development. There also is still the potential for C and M-flares to be observed from AR2907 but this region has now rotated off the Earth facing disc meaning it isn't possible to assess the current complexity. All other regions are currently small, and relatively simple. Solar Activity is expected to be Low, with a chance of rising to Moderate from any M-flares (R1/R2 radio blackout), and a slight chance of becoming High (R3 blackout) from any flaring of these regions. This risks falls slightly during day 2 (27 Dec) as AR2907 rotates further away from Earth, but with an ongoing risk mainly from AR2916.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	35	25	20	20
Very Active	R3 to R5 X Class	No	10	7	5	5

Figure 4: X-ray flux from the last 24 hours



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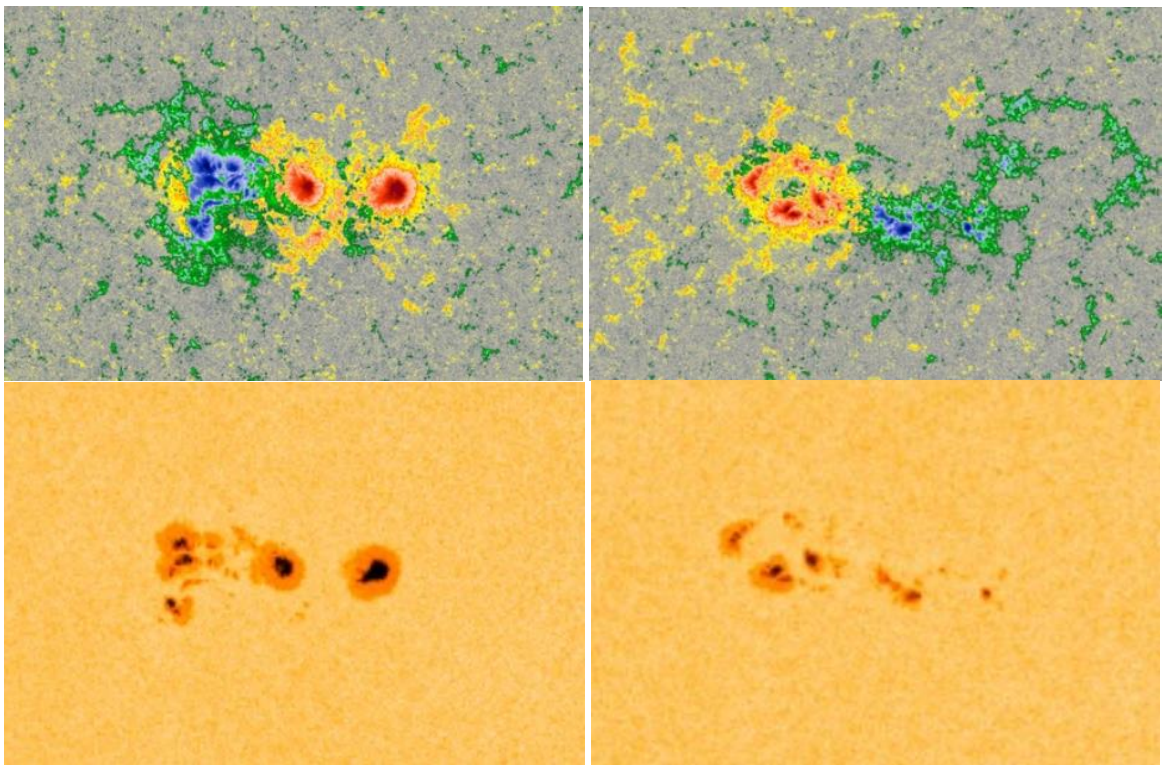
Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at background levels and expected to persist at these levels. There is a slight chance of these levels rising, however, from any notable flares from AR2916. AR2907 is still considered to be a potential source for any proton storms as well, despite now being beyond the east-limb horizon, as any proton rich eruption could still be carried to Earth along the Parker Spiral.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	5	3	3	3
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 5: AR2916 (left) and AR2918 (right).



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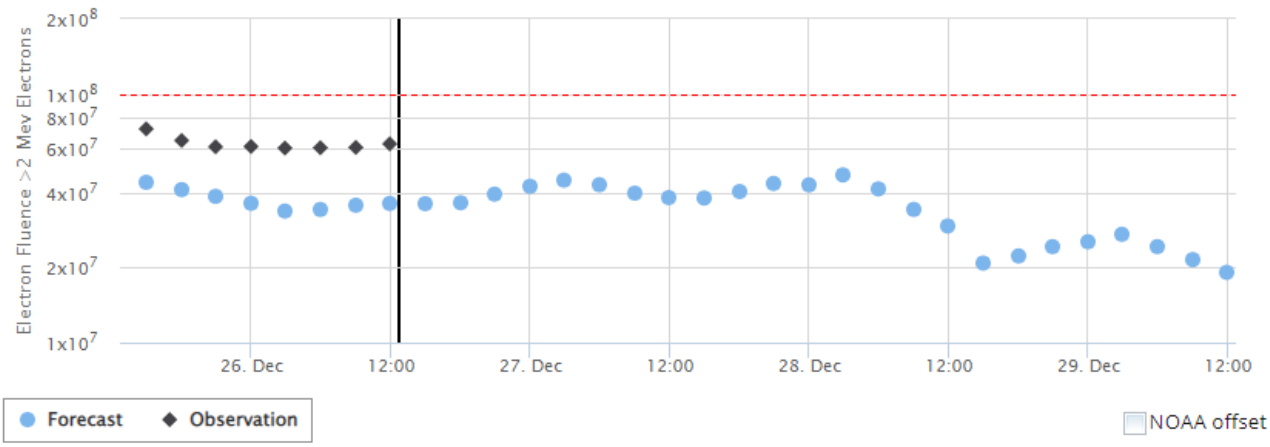
High Energy Electrons Event (≥ 2MeV):
The high energy (greater than 2MeV) electron flux, as observed by GOES-16, has been mainly moderate. Peaks at high levels are likely at diurnal max, however the arrival of the fast wind of coronal hole 37 on days 2 or 3 (27 or 28 Dec), and subsequently coronal holes 38 and 39 on days 3 or 4 (28 or 29 Dec), could drop observed flux levels to background for a time as the radiation belts compress. A re-enhancement could then subsequently occur as any compression of the radiation belts recedes. Moderate to High levels are then possible day 4.

The associated 24 hour fluence is likely to persist below the Active threshold. This is supported by REFM which is currently giving a good guide. Fluence levels are expected to rise from day 3 onward, in response to the increased flux, with a slight chance of rising above the Active threshold during day 4.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	5	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 6: REFM showing a gradual declining trend



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